STUDY OF VALUE ENGINEERING IMPLEMENTATION AMONG CONTRACTORS IN MALAYSIA

MAZBY ZUBIR KHAIRUL NAZRI BIN ZAINAL

CIVIL ENGINEERING

UNIVERSITI TEKNOLOGI PETRONAS

JUNE 2008

CERTIFICATION OF APPROVAL

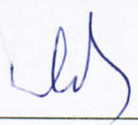
Study of Value Engineering Implementation Among Contractors In Malaysia

by

Mazby Zubir Khairul Nazri Bin Zainal

A project dissertation submitted to the
Civil Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(CIVIL ENGINEERING)

Approved by,



(Associate Professor Ir. Dr. Arazi bin Idrus)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2008

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MAZBY ZUBIR KHAIRUL NAZRI BIN ZAINAL

ABSTRACT

This project is a study or research of implementation of Value Engineering (VE) in Malaysia's construction industry focusing among the Class A to Class C contractors in Peninsular of Malaysia.

The objectives of this research project are to investigate the level of awareness, implementation and the current state of VE in Malaysia's construction industry. In 2003, a research is done on this matter and it shows that the implementation is very low. There is no research done since then and it is very important to investigate the recent level of awareness and implementation in the industry because the outcome could be different from the previous research. If the no changes or the level of awareness and implementation is decreasing, the latest outcome could be used as a reference for the govern body such as Construction Industry Development Board (CIDB) to promote VE in the industry since construction industry in Malaysia contribute important element in the economy. Even it is less than 5% of the national's Gross National Product, it has extensive linkages with the rest of the economy in this country.

To carry out this research, comprehensive literature review is done to provide the background and history of VE, key terminology and definitions of VE, approaches to VE in construction as well as previous study. Survey questionnaires and semi structural interviews is also used to achieve these objectives. These two methods will provide information on the awareness and perception of VE among construction professionals. From the research, it is found that the level of awareness of VE is average to high while the level of implementation is above average. Its current state of implementation is determined as widely implemented among those who implement VE.

It is hope that this study will contribute as a step to establish a framework for successful implementing VE in Malaysia's construction industry.

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to my supervisor, A.P. I.R. Dr. Arazi bin Idrus, for his continuous support, guidance, encouragement and concern throughout the whole process of making this thesis possible.

Heartfelt gratitude is also dedicated to my tutor, Mr. Christiono Utomo and all of my course mates, who never hesitated to help when I needed them. Without their guidance and valuable information, this thesis would not be completed in time.

Last but not least, thanks to all the respondents involved in the survey process. Thanks also to persons interviewed for useful feedbacks. Without their responds, there would be no data for me to analysis in order to produce results. Therefore, I would like to thank whoever that was involved in this project.

MAZBY ZUBIR KHAIRUL NAZRI BIN ZAINAL
BACHELOR IN CIVIL ENGINEERING
UNIVERSITY OF TECHNOLOGY PETRONAS

JULY 2008

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1
INTRODUCTION

1.1 Background Study

Value Engineering (VE) in general is defined as an analysis of materials, processes, products in which function is related to cost and from which a selection may be made to achieve the desired function at the lowest overall cost consistent with performance. It also could be defined as functional analysis methodology that identifies and selects the best value alternative for designs, materials, processes, systems, and program documentation. Mathematically, VE can be determined as:

$$\text{Value} = \frac{\text{Function}}{\text{Cost}}$$

Source: Kumar, S., Singh R.K., Jha, S.K. (2005)

It has been used successfully in construction industry in many countries since Lawrence Miles first developed it after World War II. The application is proved as powerful management methodology in overseas as it can significantly improve the value for money that clients received in construction industry. Although VE is important in the industry, it has not become fertile land for its growth in Malaysia. It is necessary to understand the current state of VE application in Malaysia's construction industry as in order to promote its development as it provides useful management tools to the industry.

From previous research, Value Engineering is considered at the early stage in Malaysia's construction industry. It is not very popular in Malaysia due to lack of knowledge and awareness of its implementations. Ong (2003) in Ng KL (2003) stated that Value Management can be considered still at the early stage and only several construction projects applied the method. Mohd Zainuddin (2000) in Ng K.L. (2003) also stated that not more than 10% of construction firm practiced value management to reduce their actual cost due to lack of knowledge.

1.2 Problem Statement

As stated in background of study, it is shown that the awareness of Value Engineering in this industry is still low despite of the advantages of its implementation in the industry. Despite, there is no research on this matter since then. It is necessary to investigate the current state of awareness and implementation of VE in construction industry in Malaysia to see whether the level of awareness and implementation has increased from the previous research.

1.3 Significance

It is hope that this study will contribute as a step to establish a framework for successful implementation of VE in Malaysia's construction industry. It is also hope that it can be used by govern body of Malaysia's construction industry, Construction Industry Development Board (CIDB) for their action in promoting VE in the industry in future.

1.4 Objectives

- To determine the level of awareness of value engineering in Malaysia's construction industry.
- To investigate the current state of VE implementation in Malaysia's construction industry.
- To determine the level of implementation of VE in Malaysia's construction industry.

1.5 Scope of Study

- Survey conducted around people who involved in the industry in Malaysia, particularly among large size contractors in Peninsular Malaysia.
- Investigate the level of awareness and implementation of VE among Class A to C contractors in Peninsular Malaysia.

CHAPTER 2
LITERATURE REVIEW

2.1 Value Engineering (VE)

Value Engineering is a systematic and creative way of analyzing an item, system, process, and facility etc for the purpose of identifying essential function and alternate methods to satisfy those essential functions in the most cost-effective manner. The normal result of application of VE is a decrease in cost while improving quality, reliability, durability, effectiveness and other desirable characteristics.

2.2 History of VE

Value engineering process was developed by Lawrence Miles, an electrical engineer for General Electric Company during World War II. It is response to material shortages created by the war. Lawrence Miles discovered that many of the products being produced with the substituted materials performed the equivalent function of the original product and at a reduced cost. In reviewing these cost reductions, Miles determined that if an organized team approach was established to review product designs and specifications, unnecessary costs within the production of a product could be eliminated.

In the 1950's, Miles developed the organized team approach known as the **job plan** which has become the framework to any formal value engineering study. There are several jobs plan formats depending on which agency's format are followed. The individual steps in the various job plan formats may vary in the number of steps and title of each step. However, the process of the job plan is the same concept no matter which format is followed.

2.3 VE Job Plan

VE job plan is a formula or steps to be taken in order to complete its process. These are the typical job plan process (Younker, D.L., 2003):

- Information Phase
- Creative Phase
- Evaluation Phase
- Planning Phase
- Reporting Phase
- Implementation Phase

Information phase is the longest and most complex step in VE process. It covers the orientation of project, determination of project cost, project goal setting and the definition of *function* of the project. Creative phase is the process where alternatives in order to enhance projects *value* and evaluation phase is the process of screening and evaluating all the alternatives determined from the creative phase. This process will eliminate alternatives that have no potential use. In planning phase, the usable alternatives will be organized and the concept for further development is created. In this phase, plan recommendation also been made. Before the implementation phase, the job plan will undergo reporting phase whereby the plan recommendations made in previous phase are organized and further actions are recommended.

2.4 Benefits of VE Implementation

The implementation of VE provides many benefits to all parties. The positive impacts not only affected towards the people who involved in the construction industry, but also to the public. These are the list of benefits of VE implementation (Ong, H.T., 2003):

- Elimination of unnecessary cost
- Achievement of value of money
- Higher value and quality
- Encourage team work
- Provide more focus on client's expectation and project's objective
- Provide alternatives as well as better choice in order to complete the project
- Give positive image to the public as better value is achieved

- Reduction of time and cost
- Improve the effectiveness of resources
- Encourage creativity and innovation among project team members

2.5 Improving Value in VE

As *Cost* is measurable, VE in normally associated with cost reduction which will result better implication for our economy. VE could produce a better *Value* for a material or project by eliminating or modifying any element that significantly contributes to the overall cost without adding equal value to the overall function. These could reduce the actual cost while its function such as quality, reliability, durability, effectiveness and etc are improved. It also could improve profit and shortened the construction duration as cost, time and quality are the three constraints in construction management. Table 2.1 shows the fundamental on how *Value* could be improved under several conditions.

Table 2.1: Improving Value under Various Conditions

Function	Cost	Comment
↑	Constant	If Cost is constant, Value could be increased by increasing the Function.
Constant	↓	If Function is constant, Value could be increased by decreasing the Cost.
↑↑	↑	If Cost is increased, Value could be increased by double-increase the Function.
↓	↓↓	If Function is decreased, Value could be increased by double-decrease the Cost.

2.6 VE in Construction Industry

In construction industry, VE is applicable in many stages. It could be implemented during the design stage (design concept and design) and construction stages.

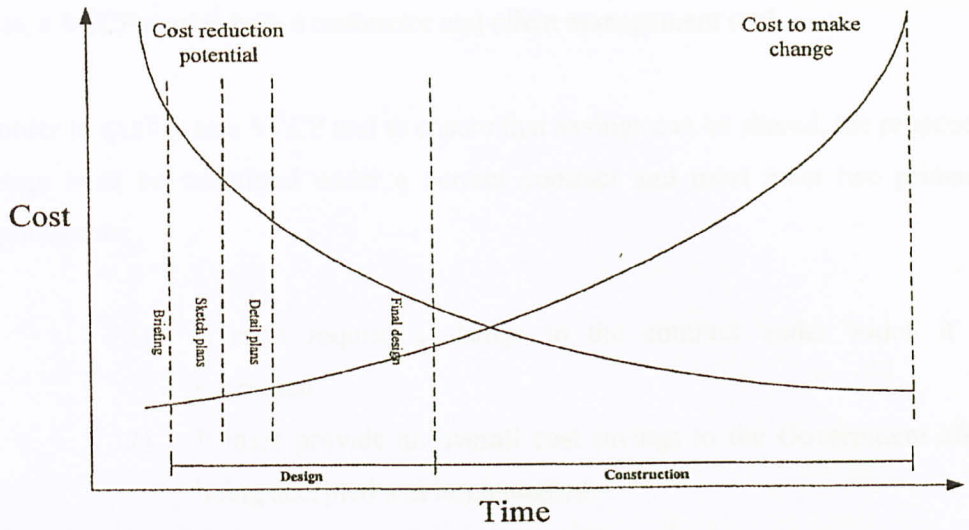


Figure 2.1: Cost vs Time on VE Implementation

Source: Department of Defence (2003)

As shown in Figure 2.1, the potential of cost reduction is better during the design stage. Despite the effectiveness is high during design stage, it is preferable that it is applied in both stages to maximize the Value of a project. For example, under an inflexible schedule, the designers often incorporate "typical, reliable" components or subsystems into the design due to time constraint. In this condition, VE can be applied during the construction stage by the initiative of the contractors to implement VE in order to produce better value for the project.

In applying VE during the construction stage, contractors could propose the VE Change Proposal to the client or consultant (client representative). It proposes a change that, if accepted and implemented, provides an eventual, overall cost savings to the client. A VECP may be a change that updates an existing design to the current state-of-the-art technology, simplifies complex material by modifying or eliminating components, updates specifications/drawings providing improved data for future procurements, or reduces Contract Data Requirements List (CDRL) items, to name a few examples. The VE requirements in a contract prescribe that the contractor receives a substantial share in the savings accrued as a result of implementation of the change. In other words, a VECP provides a vehicle through which acquisition

and operating costs can be reduced, while the contractor's rate of return is increased. Thus, a VECP can be both a contractor and client management tool.

In order to qualify as a VECP and to ensure that savings can be shared, the proposed change must be submitted under a current contract and must meet two primary requirements:

1) It must require a change to the contract under which it is submitted.
2) It must provide an overall cost savings to the Government after being accepted and implemented.

2.7 VE in Malaysia

In Malaysia, this concept was highlighted on 9th October 2001 with the establishment of Institute of Value Management Malaysia (IVMM) (Ng Kim Lai, 2006). Even though it was highlighted in 2001, it is still not popular in Malaysia's construction industry by now.

Value Engineering is considered at the early stage in Malaysia's construction industry due to lack of knowledge and awareness of its implementations. Ong (2003) in Ng K.L. (2003) stated that Value Management can be considered still at the early stage and only several construction projects applied the method.

Mohd Zainuddin (2000) in Ng K.L. (2003) also stated less than 10% of construction firm practiced value management to reduce their actual cost due to lack of knowledge. Besides, Choo (1998) in Ng K.L. (2003) also stated that quite a few of Malaysian contractors are not in favor of Value Engineering as they prefer to minimize cost without considering the quality, functionality and safety of the structure that has been built.

Some of the professionals in the industry stated that VE is not popular in Malaysia because it does not provide economical benefits to the contractors.

2.8 Previous Research on VE in Malaysia

There are several researches done regarding this topic. The last research done on this matter was in 2003 which stated that VE implementation is still at the early stage. It is also found in the research that the degree of understanding of VE was average.

But since then, no other research was done. Despite, the research is investigated VE implementation towards both consultant (for design stage) and contractor (for construction stage). The researches generally investigate VE implementation in the industry itself and factors that hindering the application.

As there is no research of VE implementation particularly towards the contractors, it is important to investigate VE implementation towards them as to reveal the current level of awareness and implementation among the contractors.

CHAPTER 3
METHODOLOGY

The methodology of this research is shown in Figure 3.1 below.

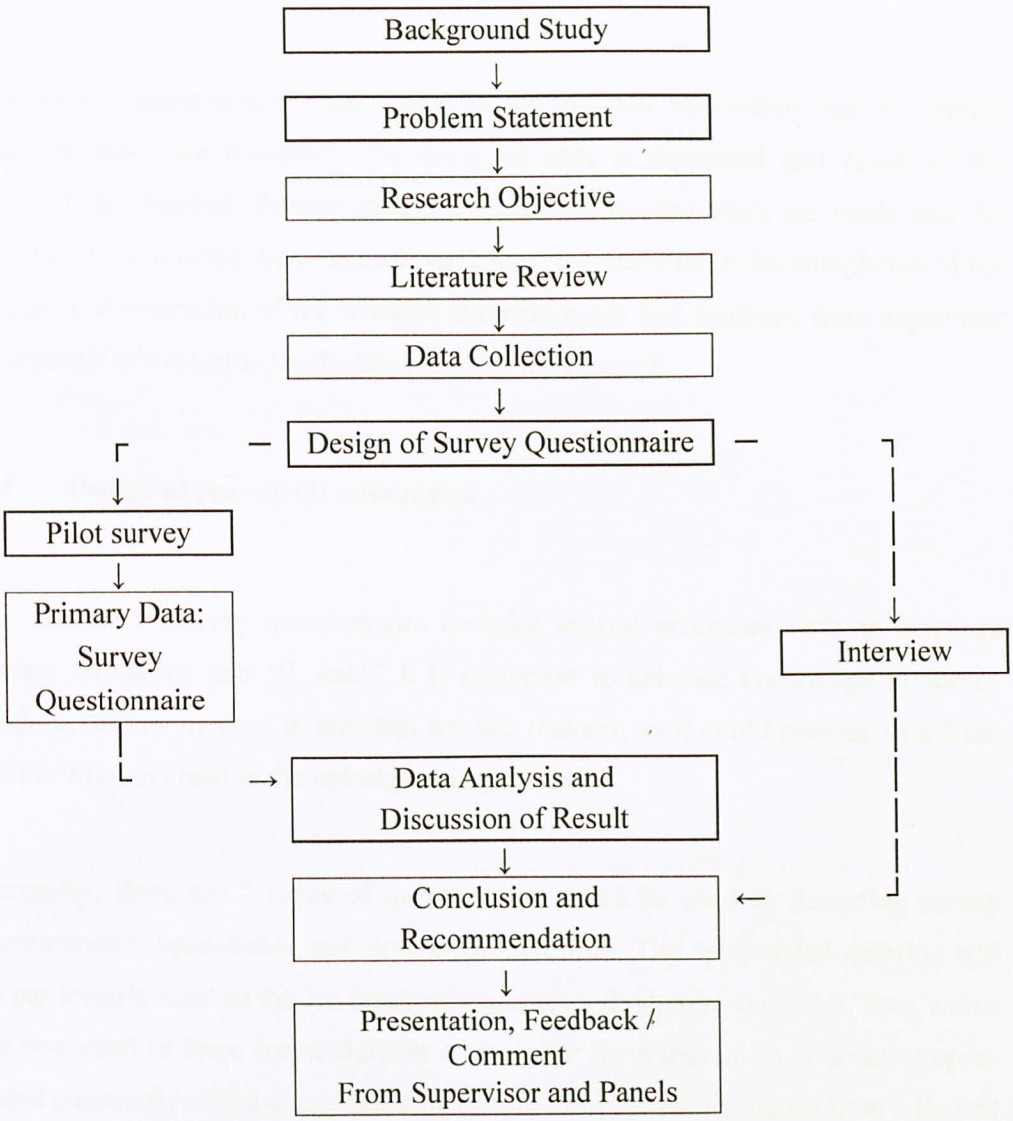


Figure 3.1: Research Methodology Flow Chart

This research had undergone several stages before completion. Comprehensive literature reading is undertaken in obtaining the overall understanding of VE, including background and history, important terminology and definitions, job plan and tools used in implementing VE in construction.

The first draft of survey questionnaire is designed in determining the objectives of the research. As it is completed, pilot survey is done on some in determining the workability of the questionnaire. Outcomes and comments from the pilot survey are taken into consideration in the second draft questionnaire.

The survey questionnaires are posted to the targeted respondent and the replied questionnaires are analyzed. The analyzed data is discussed and result of the research is obtained. Several interviews with the professionals are made and the research is concluded. Some recommendations are made upon the completion of the research. Presentation of the research and comments and feedback from supervisor and panels of evaluator are the final stage of the research.

3.1 Design of Survey Questionnaire

The design of survey questionnaire includes several processes such as literature review on survey and VE itself. It is important to enhance knowledge in survey method. Survey method is practical for this research as it could provide data from people who involved in the industry in large amount.

Generally, there are 2 types of question that could be used in designing survey questionnaire; open-ended and close-ended question. The open-ended question will be particularly used as the ice breaking question and when respondents' own words are important or there are no definite answers for the question. In contrast to open-ended questions, closed-ended questions require respondent to choose from a limited number of responses predetermined by the researcher. The questions provide primarily quantitative data, and are frequently used in confirmatory research.

In designing the questionnaire, both types of question are used. But in determining the objective of this research, close-ended question is widely used as it could provide the answer in a scale format and this will help the respondents answer it in a short period. It is also easier to carry out analysis of the outcome from close-ended question rather than open-ended question.

The survey questionnaire for this research is designed to reveal the objective of this research as stated in item 1.4. It is divided into 5 sections; Section A, B, C, D and E.

Table 3.1: Description of Survey Questionnaire

Section of Questionnaire	Description
A. General / Background Information	Contains open-ended questions on company and respondent's background such as name, years of involvement in construction industry and etc.
B. Level of Awareness of Value Engineering	10 questions asking respondent familiarity and awareness with VE. It also contains some questions that asking for the current level of VE implementation in respondent's current project.
C. Level of Implementation of Value Engineering	4 questions that asking for respondents' experience on level of implementation of VE in the industry.
D. Other Information	An optional question asking respondents' additional personal comment / opinion about VE in Malaysia's construction industry.
E. Feedback	Some short question asking if respondent willing to have a copy of the research final report and to be contacted for further information.

3.2 Population and Sampling

The population of is the contractors in Peninsular Malaysia as the research is focusing towards contractors in Malaysia. There are 7 classes of contractors classified by Construction Industry Development Board (CIDB) and Pusat Khidmat Kontraktor (PKK). The details of contractors in Malaysia are shown in Table 3.2:

Table 3.2: Classification of Contractors in Malaysia

Registration Grade (CIDB)	Registration Class (PKK)	Minimum Paid Up Capital (RM)	Minimum Project Price (RM)	Category / Size
G1	F	5 000	< 100 000	Small
G2	E & EX	25 000	< 500 000	Small
G3	D	50 000	< 1 000 000	Small
G4	C	150 000	< 3 000 000	Medium
G5	BX	250 000	< 5 000 000	Medium
G6	B	500 000	< 10 000 000	Medium
G7	A	750 000	No limit	Large

The research are focusing towards Class A to Class C (PKK) because they are medium to large contractors.VE is considered more effective among them compared to the other classes as their minimum project price is very high and the possibility of cost-saving to these contractors are higher. These contractors are tracked from Construction Industry Development Board (CIDB) directory *(http://www.cidb.gov.my/cidbweb/directory/cont-my.html).* The sampling of the respondent is 60% Class A, 30% Class B and 10% Class C (PKK) contractors.

3.3 Pilot Survey

Pilot survey is done on 5 respondents consist of lecturers and professionals in the industry. The objectives of carrying out the pilot survey are:-

- To ensure that the questions asked are enough to reveal the objective of the research.
- To ensure that the questions asked are relevant to the research.
- To ensure that questions are clear enough to understand.

3.4 Interview

Follow up interviews is used in this research as a confirmation or to add more information of VE from the respondent. The data from the sessions are tabulated in table in Chapter 4.

3.5 Tools

There are two main tools that are used in this research. For data collection, tool used is survey questionnaire. The other tool is statistical analysis which is used for analyzing the outcome from the survey questionnaire.

3.6 Data Analysis

The data from completed survey questionnaires are analyzed by statistical analysis as discussed in Chapter 4.

CHAPTER 4
RESULT AND DISCUSSIONS

4.1 Result

4.1.1 Background Information of Respondent

There are 24 respondents from various state of Peninsular Malaysia that involved in this research. The detail of respondents is shown in Table 4.1 below:

Table 4.1: Respondent's Location and Class of Contractor (PKK)

Location	Number of Respondent						Total	
	Class A		Class B		Class C			
	Freq	%	Freq	%	Freq	%	Freq	%
KL	3	13%	0	0%	0	0%	3	13%
Perak	1	4%	0	0%	0	0%	1	4%
Terengganu	1	4%	0	0%	0	0%	1	4%
Kedah	1	4%	0	0%	0	0%	1	4%
P. Pinang	3	13%	0	0%	0	0%	3	13%
Selangor	7	29%	0	0%	0	0%	7	29%
N. Sembilan	3	13%	1	4%	0	0%	4	17%
Melaka	1	4%	1	4%	1	4%	3	13%
Putrajaya	1	4%	0	0%	0	0%	1	4%
Total	**21**	**88%**	**2**	**8%**	**1**	**4%**	**24**	**100%**

4.1.1.1 Respondent Location

From Table 4.1, it is shown that respondent from 9 states involved in this research. 7 of them are form Selangor, 4 from Negeri Sembilan, 3 from Melaka, Kuala Lumpur and Pulau Pinang and 1 from Perak, Terengganu, Kedah and Putrajaya. From the data, it is also shown that majority of the respondent are from Central Malaysia (Selangor, Kuala Lumpur and Putrajaya) with 11 respondents. South Malaysia

(Melaka and Negeri Sembilan) is the second highest with 7 respondents. North Malaysia (Perak, Pulau Pinang and Kedah) is third highest with 5 respondents and East Coast of Malaysia (Terengganu) is the lowest with only 1 respondent involved.

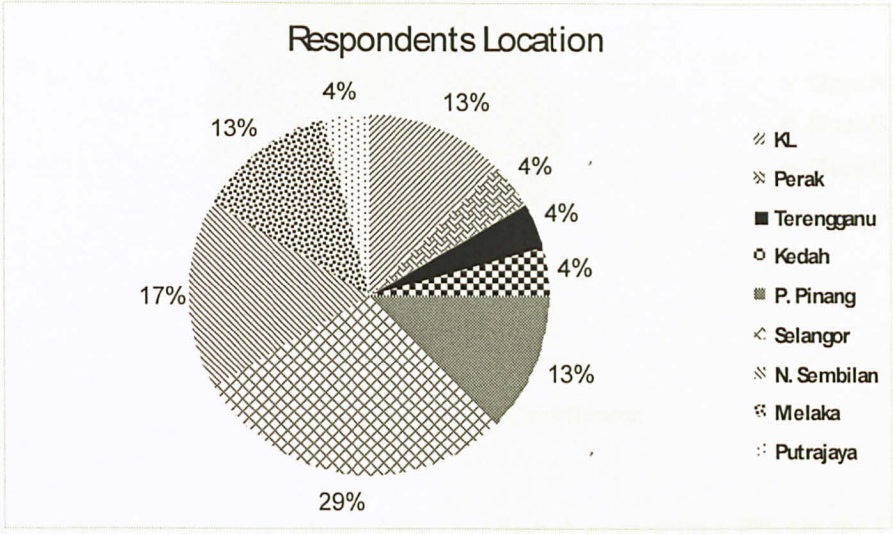


Figure 4.1: Respondents Location

As shown in Figure 4.1, the highest respondent's location is Selangor with 29%, followed by Negeri Sembilan with 17%, Melaka, Kuala Lumpur (KL) and Pulau Pinang with 13%, and Perak, Terengganu, Kedah and Putrajaya with 4%.

4.1.1.2 Respondent Classification

From Table 4.1, it is shown that most of the respondent is from Class A contractor. 21 out of 24 contractors is Class A and 2 from Class B and only 1 from Class C. Both of the Class B and C contractors are from the Southern Malaysia (Negeri Sembilan and Melaka). The percentage of respondent's classification is shown in Figure 4.2 below:

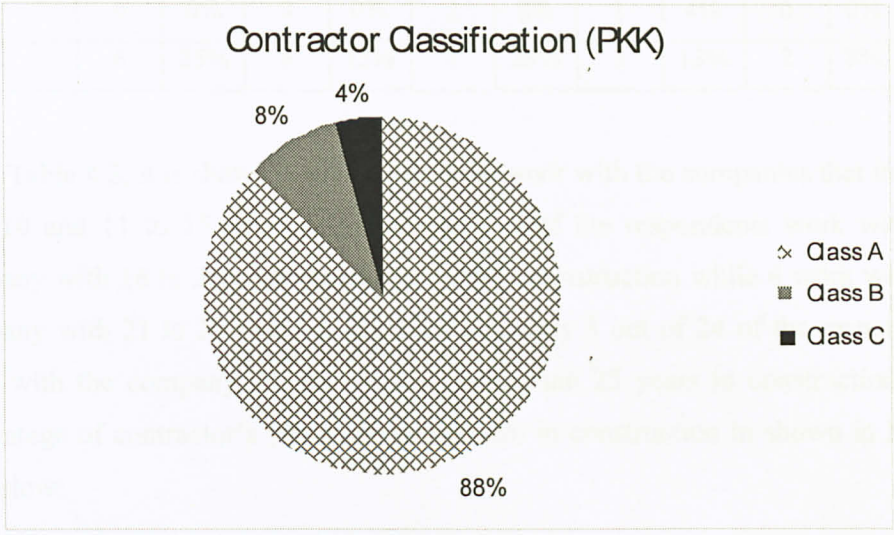


Figure 4.2: Contractors Classification

Out of the 23 contractors involved, 88% are Class A contractors, 8% are the Class B contractors and 4% are Class C contractors.

4.1.1.3 Respondent Years of Experience and Involvement in Construction

Respondent's years of experience and involvement is analyzed by dividing the duration into ranges. Years of experience is referring to the respondents experience in construction and years of involvement referring to the company involvement in construction. Details of respondent years of experience and involvement in construction are shown in Table 4.2:

Table 4.2: Analysis of Experience and Years of Involvement in Construction

Number of Contractors Years of Involvement	Number of Respondent Years of Experience										Total	
	1 - 10		11 - 15		16 - 20		21 - 25		> 25			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
1 - 10	3	13%	1	4%	2	8%	0	0%	0	0%	6	25%
11 - 15	1	4%	3	13%	0	0%	0	0%	2	8%	6	25%
16 - 20	1	4%	2	8%	2	8%	0	0%	0	0%	5	21%
21 - 25	1	4%	0	0%	1	4%	2	8%	0	0%	4	17%

> 25	0	0%	0	0%	2	8%	1	4%	0	0%	3	13%
Total	6	25%	6	25%	7	29%	3	13%	2	8%	24	100%

From Table 4.2, it is shown that 6 respondents work with the companies that involve 1 to 10 and 11 to 15 years in construction. 5 of the respondents work with the company with 16 to 25 years of involvement in construction while 4 work with the company with 21 to 25 years of involvement. Only 3 out of 24 of the respondents work with the company which involved more than 25 years in construction. The percentage of contractor's years of involvement in construction in shown in Figure 4.3 below:

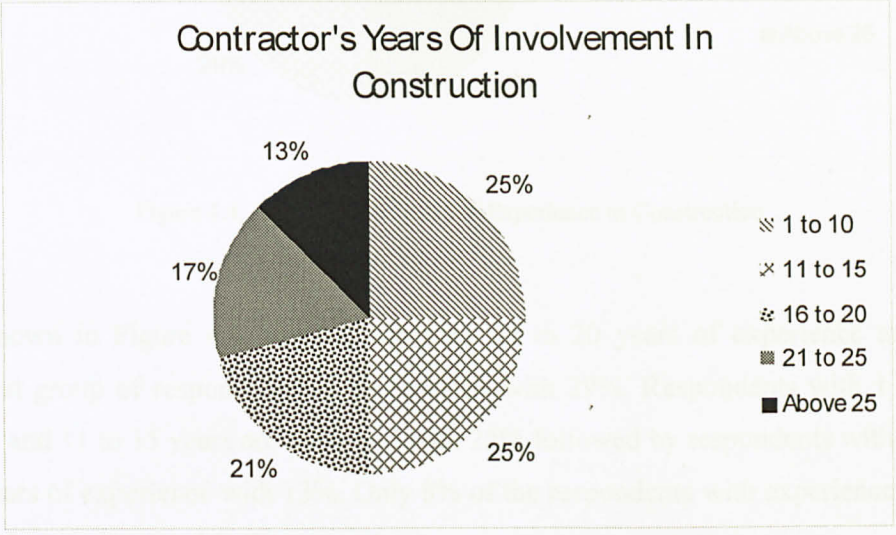


Figure 4.3: Contractors' Years of Involvement in Construction

Referring to Figure 4.3, 25% of respondents are from contractors which with 1 to 10 years and 11 to 15 years of involvement in construction. 21% of the respondent are from contractors which with 16 to 20 years of involvement in construction. 17% of the respondent are from contractors which with 21 to 25 years of involvement in construction. Only 13% of the respondent are from contractors which with more than 25 years of involvement in construction.

As shown in Table 4.2, the research is involved by respondents with various years of experience. 6 of them have 1 to 10 and 11 to 15 years experience in construction. 7

of them have 16 to 20 and 3 have 21 to 25 years of experience. Only 2 out of 24 respondents have more than 25 years experience in construction. The percentage of respondents' years of experience in construction is shown in Figure 4.4 below:

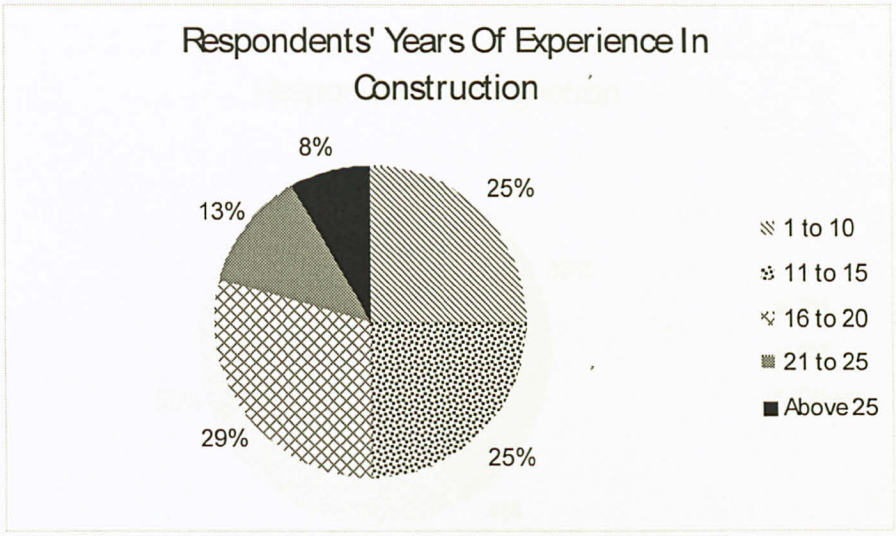


Figure 4.4: Respondents' Years of Experience in Construction

As shown in Figure 4.4, respondents with 16 to 20 years of experience are the highest group of respondents in the research with 29%. Respondents with 1 to 10 years and 11 to 15 years are at second with 25% followed by respondents with 21 to 25 years of experience with 13%. Only 8% of the respondents with experience more that 25 years involved in the research.

4.1.1.4 Respondent Designation

The respondents designation are divided into 3 groups; Project Manager (PM), Construction Manager (CM) and Other for other designation such as Site Engineer or Project Engineer. The details of respondent designation are shown in Table 4.3:

Table 4.3: Respondent Designation

	Project Manager	Construction Manager	Other
Frequency	9	1	14
Percentage	38%	4%	58%

Out of 24 respondents, 9 of them are Project Manager and only 1 of them is Construction Manager. 14 of them are in Other designation classification such as Chief Executive Office, Executive Director, Project Director, Project Coordinator, Project Engineer and Planner.

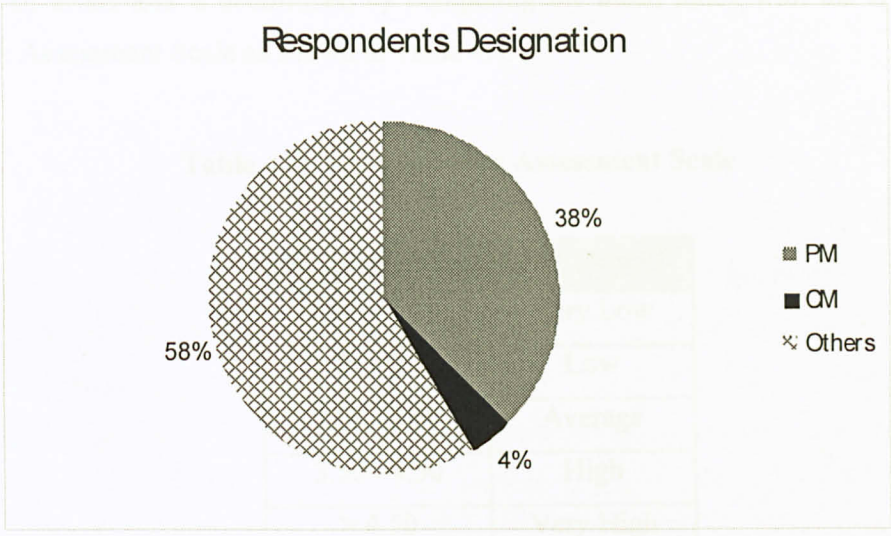


Figure 4.5: Respondents Designation

Other designation is the highest group of respondents for this research with 58% followed by Project Manager with 38%. Construction Manager are the least group of respondent for this research with 4%.

4.1.2 Level of Awareness of VE

The data collected are analyzed by average index. It is determined by (Abd Majid and Mc Caffer, 1997);

$$\text{Average Index} = \frac{\sum a_i x_i}{\sum x_i}$$

a_i = Constant expressing weight given to a_i

x_i = Variable expressing the frequency of the response for

i = 1, 2, 3, 4, 5

$\mathbf{x_1}$ = frequency of the "very rare" response and corresponding to $\mathbf{a_1}$ = **1**

$\mathbf{x_2}$ = frequency of the "rare" response and corresponding to $\mathbf{a_2}$ = **2**

$\mathbf{x_3}$ = frequency of the "slightly frequent" response and corresponding to $\mathbf{a_3}$ = **3**

x_4 = frequency of the "frequent" response and corresponding to a_4 = 4

x_5 = frequency of the "very frequent" response and corresponding to a_5 = 5

After analyzing the data and the average index of each question is determined, the level of awareness is determined by comparing the mean index with the Average Index Assessment Scale as shown in Table 4.4:

Table 4.4: Average Index Assessment Scale

Scale	Assessment
0.00 - 1.50	Very Low
1.51 - 2.50	Low
2.51 - 3.50	Average
3.50 - 4.50	High
> 4.50	Very High

(Source: Abd Majid and Mc Caffer, 1997 in Mohd Yusof, S.H., 2005)

Table 4.5 below shows the details of number of respondents' assessment for each question. It also contains the mean index as well as the awareness assessment of each question.

Table 4.5: Assessment and Mean Index of Each Question

Awareness Factor	Level of Awareness					Mean Index	Indicator
	1	2	3	4	5		
Q1. Your familiarity of term *Value Engineering* (VE).	3	1	7	6	7	3.54	High
Q2. VE is applicable in Malaysia's construction industry.	2	2	11	6	3	3.25	Average
Q3. To ensure better value for cost of your current project, your company implements VE.	2	6	5	7	3	3.00	Average
Q4. Clients can achieve better value for money if VE is implemented.	1	1	7	12	5	4.04	High

Q5. In your previous project, VE is implemented to reduce the actual cost of the project.	3	3	6	9	3	3.25	Average
Q6. VE reduces cost by creative alternative design.	1	1	8	7	7	3.75	High
Q7. Knowledge of VE or similar terms.	2	2	7	11	2	3.38	Average

From Table 4.5, it is shown that the mean index of Question 1 is 3.54 which indicated the level of awareness for this question is high. The mean index for Question 2 and 3 are 3.25 and 3.00 which indicated the average level of awareness for both questions. Question 4's mean index is 4.04 which is high level of awareness and Question 5's is 3.25 which is average level of awareness. The two last questions; Question 6 and 7 have mean index of 3.75 and 3.38 which are high and average level of awareness. The level of awareness of each question is shown in Figure 4.6 for better view.

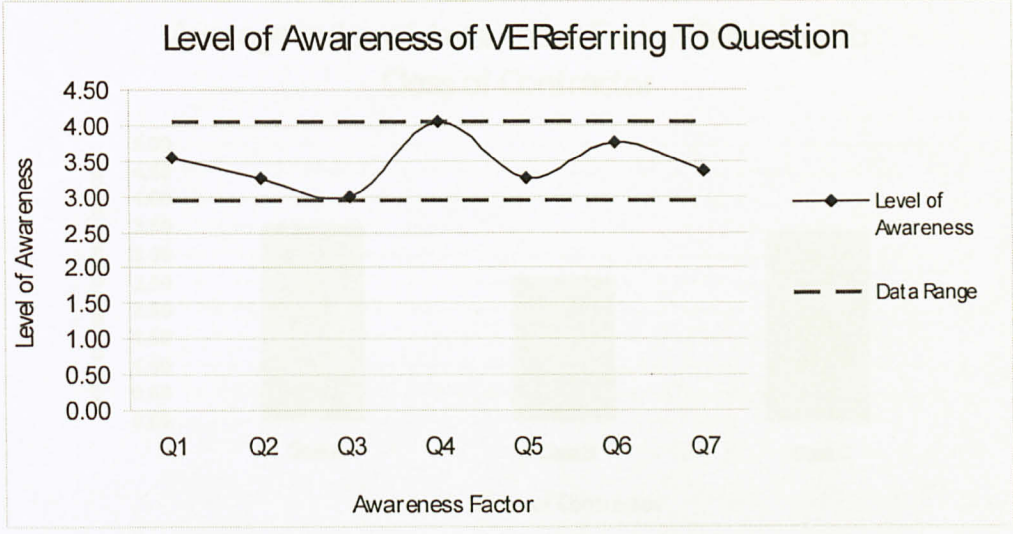


Figure 4.6: Level of Awareness of VE Referring To Question

Figure 4.6 shows the level of awareness for each question in the solid line and the range of level of awareness in the dashed lines. It is determined that the respondents had high awareness of familiarity of VE terms. Besides that, the respondents also very aware that client could achieve better value for money if VE is implemented and VE could reduce cost by creative alternative design. Other than that, the

respondents only had average level of awareness of the applicability and knowledge of VE.

Table 4.6: Average Index Referring To Class of Contractor

	Average Index Each Awareness Factor							Average Index	Indicator
	1	2	3	4	5	6	7		
Class A	3.71	3.38	2.95	4.10	3.29	3.90	3.48	3.54	High
Class B	2.00	2.00	3.00	3.50	2.50	2.50	2.50	2.57	Average
Class C	3.00	3.00	4.00	4.00	4.00	3.00	3.00	3.43	Average

It shown that average index for Class A contractors is 3.54 which indicated that the level of awareness of VE among them as high. For Class B and C contractor, the average index is 2.57 and 3.43 which is indicated average level of awareness. The average index of awareness level is shown in Figure 4.7 for better view. From both Table 4.6 and Figure 4.7, it is determined that the level of awareness is ranging from average to high.

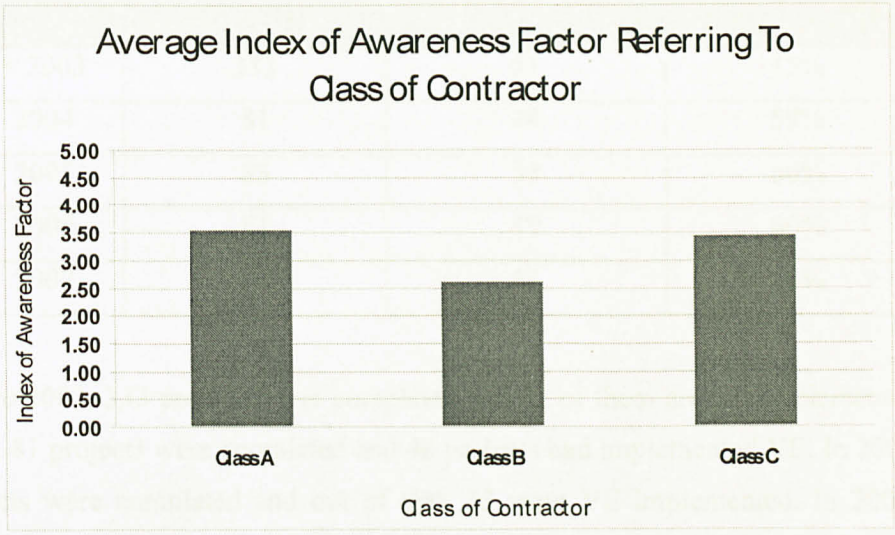


Figure 4.7: Average Index of Awareness Factor Referring To Class of Contractor

From the analysis, it is determined that the level of awareness is **average to high** as the mean index referring to each question and class of contractor ranges from that level of indication.

4.1.3 Level of Implementation of VE

Level of implementation of VE is analyzed by the percentage of VE implemented projects to completed projects in years before 2003 up to 2007. The percentage of VE implementation is determined by;

$$\textbf{Percentage of VE Implementation} = \frac{\sum \text{VE implemented projects}}{\sum \text{Completed projects}} \times 100\%$$

The sum of Completed projects and VE implemented projects in years are calculated by adding the total number of respected projects of each respondent. The summary of VE implemented project percentage in years is shown in Table 4.7.

Table 4.7: Summary of Percentage of VE implemented Project in Years

Years	∑ Completed projects	∑ VE implemented projects	Percentage of VE Implementation
< 2003	333	51	15%
2004	81	48	59%
2005	83	55	66%
2006	81	49	60%
2007	95	63	66%

Before 2003, 333 projects were completed and 51 of them are VE implemented. In 2004, 81 projects were completed and 48 projects had implemented VE. In 2005, 83 projects were completed and out of that, 55 were VE implemented. In 2006, 81 projects were completed and 49 were VE implemented while in 2007, 95 projects were completed and 63 were VE implemented. Figure 4.8 shows the percentage of VE implemented project in years.

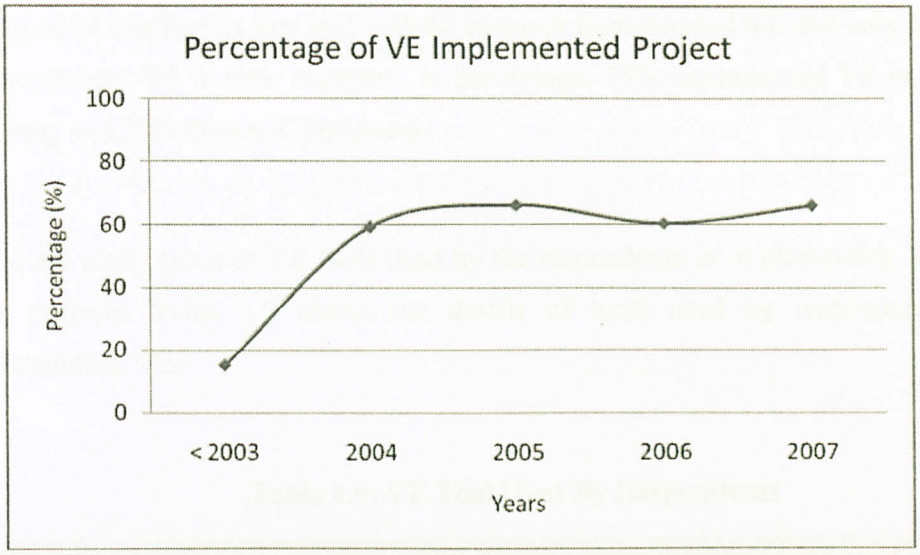


Figure 4.8: Graph of Percentage of VE implemented Project versus Years

Before 2003, the percentage is only 15% and it increased to 59% in 2004. By 2005, the percentage increased to 66% and decreased slightly to 60% in 2006. In 2007, the percentage increased to 66%.

The level of implementation is determined as **above average** as it ranges around 60% to 65% for since 2004 to 2007. The percentage in before 2003 is not considered as the duration for might be ranges up to 1980s or only in the early 2000s.

4.1.4 The Current State of VE implementation

The current state of VE implementation is determined by respondents' usage of VE tools in implementing VE. The first step in determining the result is identifying the number of contractors that implement VE in their projects. Table 4.8 shows the summary of contractor that implemented VE.

Table 4.8: Summary of Contractor That Implemented VE

	Contractor Implement VE	Contractor Not Implement VE
Frequency	18	6
Percentage	75%	25%

18 out of 24 contractors that involved the research implemented VE and only 6 that not implement VE in their company. In percentage, 75% implemented VE in their company and 25% does not implement.

There are many types of VE tools used by the respondents in implementing VE in their projects. Table 4.9 shows the details of tools used by respondents in implementing VE.

Table 4.9: VE Tool Used By Respondents

VE Tools		Number And Percentage of Respondent Referring To Class of Contractor						Total	%
		Class A		Class B		Class C			
		Freq	%	Freq	%	Freq	%		
Information Stage	Function Analysis	6	9	0	0	0	0	6	14%
	Pareto Analysis	1	2	0	0	0	0	1	
	Full VE Job Plan	2	3	0	0	0	0	2	
Creative Stage	Creative Thinking	12	18	0	0	0	0	12	42%
	Brainstorming	9	14	1	2	1	2	11	
	Cost Model	2	3	1	2	1	2	4	
Analysis Stage	Cost Function Analysis	7	11	0	0	0	0	7	45%
	Cost Breakdown Analysis	12	18	1	2	1	2	14	
	Evaluation Matrix	2	3	0	0	0	0	2	
	Life Cycle Cost	2	3	0	0	0	0	2	
	Other Multicriteria Decision Making	4	6	0	0	0	0	4	

From Table 4.9, it is shown that all tools were used by the respondents in implementing VE. There are specific tools for each stages of the construction. In Information stage, Function Analysis, Pareto Analysis and Full VE Job Plan are used to gather all information related in identifying the function of the project.

During the Creative Stage, Creative Thinking, Brainstorming and Cost Model are used to find alternatives to the function of the projects. In the Analysis Stage, Cost Function Analysis, Cost Breakdown Analysis, Evaluation Matrix, Life Cycle Cost and Other Multicriteria Decision Making are the tools used in analyzing the alternatives determined in the previous stage. The frequencies of tools used are shown in Figure 4.9.

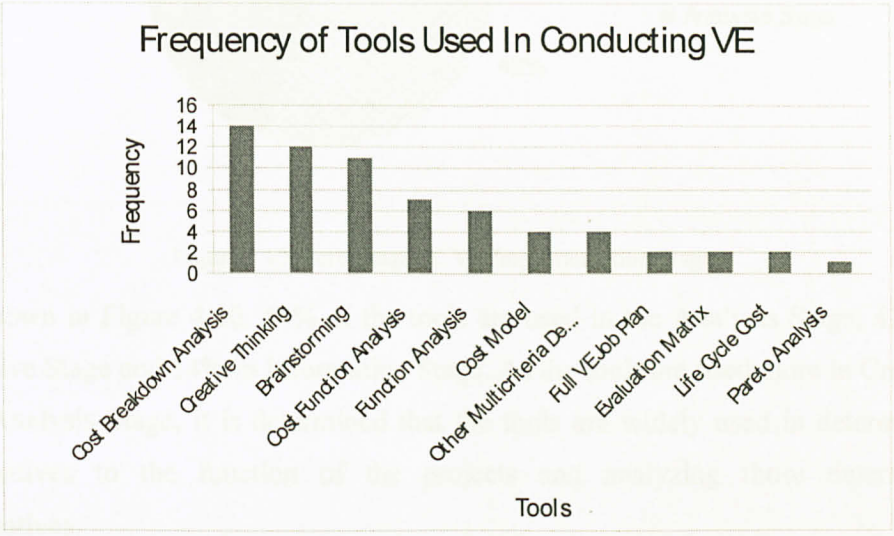


Figure 4.9: Number of Tools Used in Conducting VE

Cost Breakdown Analysis is has the highest frequency with 14 followed by Creative Thinking and Brainstorming with 12 and 11. Cost Function Analysis and Function Analysis is the forth and fifth highest tool used with 7 and 6 while Cost Model and Multicriteria Decision Making are the sixth highest tool used with 4. Full VE Job Plan, Evaluation Matrix and Life Cycle Cost are the second lowest tool used with 2 and Pareto Analysis is the lowest with only 1. The percentage of VE implementation stages is shown in Figure 4.10.

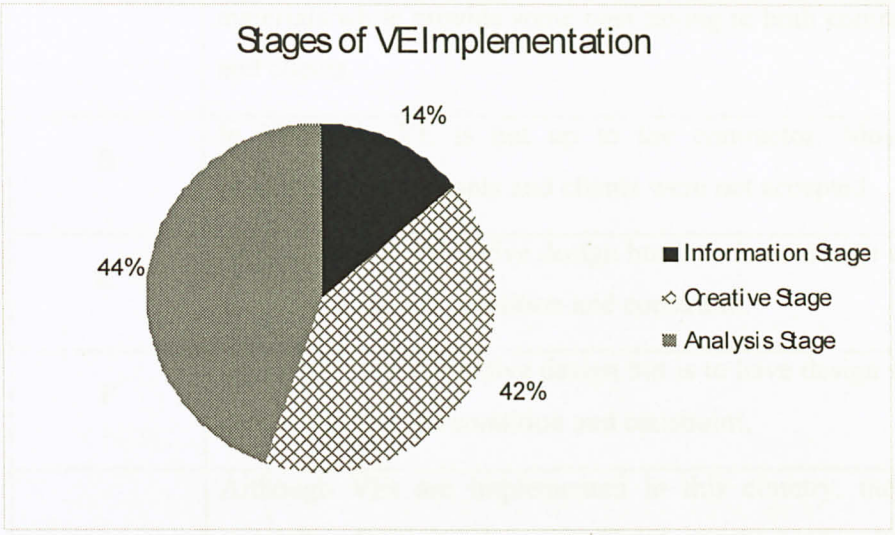


Figure 4.10: Percentage of VE Implementation Stages

As shown in Figure 4.10, 44% of the tools are used in the Analysis Stage, 42% in Creative Stage and 14% in Information Stage. As the tools are used more in Creative and Analysis Stage, it is determined that the tools are widely used in determining alternatives to the function of the projects and analyzing those determined alternatives.

The current state of VE implementation is determined as **widely implemented** among those who implement VE. This is because all tools are used in implementing VE and the implementation is more in the stages that VE is more effective.

4.1.5 Other Information

The section D in the questionnaire is optional. The comments by the respondent about VE in Malaysia's construction industry are shown in Table 4.10:

Table 4.10: Comments of Respondents about VE in Malaysia's Construction Industry

Respondent	Comment
A	VE is been carried out to enhance the constructability based on site conditions and easy/fast availability of construction

	materials while provide some cost saving to both contractors and clients.
B	In Malaysia, VE is not up to the contractor. Most VE proposed to consultants and clients were not accepted.
C	VE is not only alternative design but is to have design which best suit to the site condition and constraint.
F	VE is not only alternative design but is to have design which best suit to the site condition and constraint.
G	Although VEs are implemented in this country, they are normally done in very unofficial manner whereby, no specific documentation is being done along the way. It is normally initiated by a person or a group of highly technical personnel who foresee the advantages of carrying out VE, mostly based on experience. The effect will be realized when looking at the project's bottom line.
I	VE should be exposed by govern body to others in the industry.
V	The trick on VE is the stage of its implementation. We find that VE should be implemented in all stages of the project development. However, major VE should be done at conceptual stage in order to fit our budget.

4.2 Discussions

4.2.1 Pilot Survey

Outcomes from the pilot survey are very useful in refining the questionnaire so that it is effective for this research and for both parties (researcher and respondents). The comments are shown in Table 4.11.

Table 4.11: Comments on Pilot Survey

Section	Comment
A. General Background	• Name of respondent should not be included. • Respondents / Company involvement in Malaysia's construction industry should be asked using close-ended question. Eg: in ranges
B. Level of Knowledge and Awareness of VE	• Re-arrange the questions.
D. Other Information	• Change the questions into close-ended questions (Q1 and Q2). • Make the questions (Q3 and Q4) optional questions.

Outcomes or comments from the respondents are taken into consideration. Second draft questionnaire are designed based on the comments and discussions with supervisor. The questionnaire refinement will take several times to assure that it is effective for both parties (researcher and respondents) as stated before.

4.2.2 Design of Survey Questionnaire

The questionnaire is divided into 5 sections. For the section A, the questions asked are more towards respondents' background and involvements' as well his / her company in Malaysia's construction industry. It would reflect their experience in the industry.

For section B, the questions asked are more to investigate respondents' level of awareness of VE. This will help in determining the first objective of this research as they are the people who involve in the industry. The questions used are likert-scale questions as it would be easier for the respondents to answer and researcher to

analyze the outcomes. Using this type of questions also will help in reducing the overall time used to answer the questionnaire.

For section C, the questions asked are to investigate the level of implementation and the current state of implementation of VE in the industry. The type of questions used is same as used in section B.

In section D, there is only one question asked. This section provides some space for the respondents to add up their information or opinion in the case study. It is an optional question because the researcher would not like to burden the respondents to answer the question.

In section E, the respondents are asked whether they would like to have a copy of the final report of this research and are they willing to be contacted to provide additional information to support this research.

4.2.3 Respondent

The total respondents involved in this research are 23. The targeted total amount is higher but due to low response rate, the actual amount is less. The respondents are targeted to be at least 33.

4.2.4 Interview

Interview is done on several respondents in order to add on information about VE in Malaysia's construction industry. From the interview, most of them stated VE is very effective for Turnkey projects. This is because in this type of project, contractor involved from the design stage up to handing over to client. This will increase the possibility of cost-saving as the shown in Figure 2.1 (page 6). It is also stated that involvement of contractors in the early stage could widen the variation of option in selecting the alternatives in Creative Stage.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The level of awareness of VE is average to high. It is determined that the respondents had high awareness of familiarity of VE terms. Besides that, the respondents also very aware that client could achieve better value for money if VE is implemented and VE could reduce cost by creative alternative design. Other than that, the respondents only had average level of awareness of the applicability and knowledge of VE.

The level VE implementation is above average as it ranges around 60% to 65% from 2004 to 2007. The percentage before 2003 is not considered as the duration for might be ranges up to 1980s or only in the early 2000s.

The current state of VE implementation is above average among those who implement VE. This is because all tools are used in implementing VE and the implementation is more in the stages that VE is more effective.

5.2 Recommendation

This research could be used as a base for nation's construction govern body such as CIDB to promote it widely in the industry as the outcome of this research shows that the level of awareness and implementation of VE is only average and above average. This is very important as VE implementation is found only increased from low to above average from the previous research in 2003.

This research also could be used as a base for future research that hinders the implementation of VE among contractors in Malaysia. If the factors could be determined, it would be easier for CIDB to set up effective programs to widen VE implementation.

REFERENCES

Abdul Majid (1997), *Assessment of Work Performance,* PhD Dissertation. Loughborough University, UK.

Construction Industry Development Board (CIDB) directory for listed contractors *http://www.cidb.gov.my/cidbweb/directory/cont-my.html.*

Department of Defence. (2003) *Contractor's Guide to Value Engineering,* System Engineering Office.

Kumar, S., Singh R.K., Jha, S.K. (2005) *Value Engineering*. New Delhi: Narosa Publishing House.

Ng, K.L. (2003) *Value Management in Construction Industry*, Degree. Thesis, Universiti Teknologi Malaysia.

Ong, H.T. and Loh, A., (2003), Hong Kong Institute of Value Management, *Value-Managed Quality System (VMQS) ~ Towards A Value-Added Quality Management System*, Kuala Lumpur, Pro-Value Management Sdn. Bhd.

Mohd Yusof, S.H., (2005), Application of Sustainable Construction Principle in Construction Industry, Faculty of Civil Engineering, Universiti Teknologi Malaysia.

Younker, D.L. (2003) *Value Engineering: Analysis and Methodology*. Florida: Marcel Dekker, Inc.

APPENDIX

APPENDIX 1: SAMPLE OF COVER LETTER

2nd November 2007

Dear Sir/Madam,

The Implementation of Value Engineering Among Contractors in Malaysia's Construction Industry.

We seek your help in Universti Teknologi PETRONAS (UTP) research survey on the implementation of Value Engineering (VE) among contractors in Malaysia particularly around the peninsular of Malaysia.

VE is a proactive management tool that could be used in maximizing the value of a project. VE is considered and implemented as a powerful tool in construction in other countries such as China and USA.

During the economic depression in 1997, many projects in Malaysia has been on hold and abandoned. Most of the contractors did not have the ability to reduce project cost, enhance project function and shorten the project completion time. As a result, most projects facing cost overruns, low quality of work and delay in completion time.

Therefore, the objectives of this research are to identify the recent level of awareness, level of implementation as well as the state of implementation of VE among contractors in the country.

We in the Department of Civil Engineering have invented a survey questionnaire that would not take more than 15 minutes of time to complete it. We would like you to assist us by completing the questionnaire and return it back to us. With your cooperation, we should be able to gather as many data as possible regarding the research.

It is very helpful if you could complete and return the questionnaire by **8th January 2008**. As an attachment to this letter, please find a self-addressed and stamped envelope to return the questionnaire.

We thank you in advance for your support and cooperation.

Yours sincerely,

_____

(Head of Department)
Department of Civil Engineering,
Universiti Teknologi PETRONAS

Cc: Assoc Prof. Ir. Dr. Arazi Idrus
Mr Mazby Zubir Khairul Nazri Zainal

APPENDIX 2: SAMPLE OF SURVEY QUESTIONNAIRE (FIRST DRAFT)

SURVEY QUESTIONNAIRE OF VALUE ENGINEERING IMPLEMENTATION IN MALAYSIA'S CONSTRUCTION INDUSTRY

This research is carried out investigate the current level of awareness and implementation of *Value Engineering (VE)* in Malaysia's construction industry. VE is a management tools that could be used to maximize *Value* of a project without affecting the actual *Cost*. It is considered as a powerful tool in construction industry in other countries such as USA, China and etc.

The questionnaire is divided into 4 sections; Section A, B, C and D. Please answer the questionnaire by referring to the instructions given in each section.

Section A: General / Background Information
Please answer all question and tick [X] for your answer.

I. Company

i. Name of Company:
_____

ii. Classification:
1. PKK : _____
2. CIDB : _____

iii. Company's involvement in Malaysia construction industry:
_____ years

II. Respondents

i. Name of respondent:
_____

ii. Designation:
1. [ ] Project Manager
2. [ ] Construction Manager
3. [ ] Others (please specify): _____

iii. Your involvement in Malaysia construction industry:
_____ years

Section B: Level of Knowledge and Awareness of Value Engineering (VE)

This section will focus on level of knowledge and awareness on VE. Please indicate your selected answer for each question, by circling a number from 1 – 5.

1 = Very Low
2 = Low
3 = Average
4 = High
5 = Very High

	DESCRIPTION	ASSESMENT				
1.	**Your familiarity of term *Value Engineering* (VE).**	1	2	3	4	5
2.	**Knowledge of VE or similar terms.**	1	2	3	4	5
3.	**VE is enhancing tool rather than a method of cost reduction.** State your satisfactory level to the statement.	1	2	3	4	5
4.	**VE reduces cost by creative alternative design.** State your satisfactory level to the statement.	1	2	3	4	5
5.	**Clients can achieve better value for money if VE is implemented.** State your satisfactory level to the statement.	1	2	3	4	5
6.	**VE is applicable in Malaysia's construction industry.** State your satisfactory level to the statement.	1	2	3	4	5
7.	**Number of VE tools applied in your current project.** Please state the level of application.	1	2	3	4	5
8.	**In your previous project, VE is implemented to reduce the actual cost of the project.** State your satisfactory level to the statement.	1	2	3	4	5
9.	**VE is a popularly applied in your company to eliminate unnecessary cost of a project.** State your satisfactory level to the statement.	1	2	3	4	5
10.	**To ensure better value for cost of your current project, your company implements VE.** State your satisfactory level to the statement.	1	2	3	4	5

Section C: Other Information

1. How many project that your company involved for the past 5 years?

   _____

2. Out of that, how many projects that implemented VE?

   _____

3. What is your opinion on level of awareness of VE among contractors in Malaysia?

   _____
   _____
   _____
   _____
   _____
   _____

4. What is your opinion on the current state and level of VE implementation among contractors in Malaysia?

   _____
   _____
   _____
   _____
   _____
   _____

Section D: Feedback

1. Do you wish to receive a copy of the final report of this research?
   [ ] Yes, please send me a copy of the final report.
   [ ] No, do not send me any copy of the final report.

2. Would you be willing to be contacted to provide additional information to support this research?
   [ ] Yes, my contact no is _____.
   [ ] No.

Thank you for your time and cooperation in completing the questionnaire. All responses will be used for research purpose only. It would be appreciated if you could return the questionnaire before 15th January 2008.

APPENDIX 3: SAMPLE OF SURVEY QUESTIONNAIRE (SECOND DRAFT)

SURVEY QUESTIONNAIRE OF VALUE ENGINEERING IMPLEMENTATION IN MALAYSIA'S CONSTRUCTION INDUSTRY

This research is carry out to investigate the current level of awareness and implementation of *Value Engineering (VE)* in Malaysia's construction industry. VE is a management tools that could be used to maximize *Value* of a project without affecting the actual *Cost*. It is considered as a powerful tool in construction industry in many countries such as USA, China and etc.

The questionnaire is divided into 4 sections; Section A, B, C and D. Please answer the questionnaire by referring to the instructions given in each section.

Section A: General / Background Information
Please answer all questions. Put a tick [X] where applicable.

III. Company

i. Name of Company:
_____

ii. Class:
1. PKK : _____
2. CIDB : _____

iii. Company's years of involvement in Malaysia construction industry: _____ years

IV. Respondents

i. Designation:
1. [ ] Project Manager
2. [ ] Construction Manager
3. [ ] Others (please specify): _____

ii. Your experience in Malaysia construction industry:
_____ years

Section B: Level of Awareness of Value Engineering (VE)

This section focusing on level of awareness on VE. Please indicate your selected answer for each question, by circling a number from 1 – 5.

1 = Very Low
2 = Low
3 = Average
4 = High
5 = Very High

	DESCRIPTION	LEVEL OF AWARENESS				
1.	Your familiarity of term *Value Engineering* (VE).	1	2	3	4	5
2.	VE is applicable in Malaysia's construction industry.	1	2	3	4	5
3.	To ensure better value for cost of your current project, your company implements VE.	1	2	3	4	5
4.	Clients can achieve better value for money if VE is implemented.	1	2	3	4	5
5.	In your previous project, VE is implemented to reduce the actual cost of the project.	1	2	3	4	5
6.	VE reduces cost by creative alternative design.	1	2	3	4	5
7.	Knowledge of VE or similar terms.	1	2	3	4	5

Section C: Level of Implementation of Value Engineering (VE)

This section focusing on level of implementation on VE.

5. How many project that your company completed before?

< 2003:	___ project(s)	2006:	___ project(s)
2004:	___ project(s)	2007:	___ project(s)
2005:	___ project(s)		

6. In how many the above projects were VE implemented?

< 2003:	___ project(s)	2006:	___ project(s)
2004:	___ project(s)	2007:	___ project(s)
2005:	___ project(s)		

These questions are to determine the extend of VE implementation

7. Has your company implemented VE?
   [ ] Yes
   [ ] No

   If yes, please proceed to question number 4. If no, please answer question in section D.

8. What is / are the tool(s) of VE that you conducted so far? Put tick [X] at the answer(s).

☐	Function Analysis	☐	Cost Function Analysis
☐	Pareto Analysis	☐	Cost Breakdown Analysis
☐	Full VE Job Plan	☐	Evaluation Matrix
☐	Creative Thinking	☐	Life Cycle Cost
☐	Brainstorming	☐	Other Multicriteria Decision Making
☐	Cost Model		

Section D: Other Information

This section is optional.

1. What is the other information that you would like to add regarding Value Engineering in Malaysia's construction industry?

_____

_____

_____

_____

_____

Section E: Feedback

3. Do you wish to receive a copy of the final report of this research?
   [ ] Yes, please send me a copy of the final report.
   [ ] No, do not send me the final report.

4. Would you be willing to be contacted to provide additional information to support this research?
   [ ] Yes, my contact no is _____.
   [ ] No.

Thank you for your time and cooperation in completing the questionnaire. All responses will be used for research purpose only. It would be appreciated if you could return the questionnaire before 15th January 2008.

APPENDIX 4: LIST OF RESPONDENT

AFS Engineering (Malaysia) Sdn Bhd

Ahmad Zaki Sdn Bhd

Almatab Sdn Bhd

Awaludin Enterprise Sdn Bhd

Awanabiru Enterprise Sdn Bhd

BA Urusbina (Malaysia) Sdn Bhd

Bumimetro Construction Sdn Bhd

Dama Design And Build Sdn Bhd

Desa Johan Sdn Bhd

Geohan Sdn. Bhd.

Gimas Hussin Sdn Bhd

MMC-Gamuda JV

MTD Construction Sdn Bhd

NTQT Sdn Bhd

PDC Nusabina Sdn Bhd

Perspec Prime (Malaysia) Sdn Bhd

Putra Perdana Construction Sdn Bhd

Sulong Engineering Sdn Bhd

Target Resources Sdn Bhd

Teratak Aeden (JK) Development Sdn Bhd

Trans Resources Corporation Sdn Bhd

Tunas Wang Sdn Bhd

Unipenta Sdn Bhd

YMY Resources Sdn Bhd

APPENDIX 5: COMPANY'S CLASSIFICATION, YEARS OF INVOLVEMENT AND RESPONDENTS DESIGNATION, YEARS OF EXPERIENCE

Respondent	PKK			Years of Involvement	Designation			Years of Experience
	Class A	Class B	Class C		PM	CM	Others	
1	1			28			1	24
2	1			28			1	20
3	1			10			1	10
4	1			11			1	11
5	1			24	1			10
6	1			25	1			19
7	1			16			1	12
8	1			20		1		15
9	1			14	1			10
10		1		15	1			15
11	1			7	1			11
12		1		20	1			3
13			1	6			1	6
14	1			15	1			27
15	1			24			1	23
16	1			15			1	11
17	1			32			1	20
18	1			1			1	20
19	1			16			1	16
20	1			25			1	9
21	1			20	1			20
22	1			22			1	24
23	1			15			1	30
24	1			5	1			16

APPENDIX 6: LEVEL OF AWARENESS OF VE FOR EACH QUESTION

Respondent	Question No						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1	4	4	5	5	5	5	4
2	4	2	2	3	2	4	3
3	5	4	4	4	4	5	4
4	3	3	3	4	3	3	3
5	3	3	4	4	4	4	4
6	4	4	2	4	3	5	4
7	5	5	4	4	4	5	3
8	3	3	3	4	4	3	4
9	4	4	2	4	3	3	2
10	1	1	2	3	1	2	2
11	3	3	2	4	3	4	3
12	3	3	4	4	4	3	3
13	3	3	4	4	4	3	3
14	4	4	4	4	3	4	4
15	4	3	3	5	2	4	4
16	5	5	5	3	5	5	4
17	5	4	3	5	3	3	5
18	1	1	1	1	1	1	1
19	2	3	3	3	4	3	3
20	1	3	1	3	1	3	1
21	3	2	2	2	2	4	4
22	5	3	5	4	4	4	4
23	5	5	5	5	5	5	5
24	5	3	4	5	4	5	4

APPENDIX 7: NUMBER OF COMPLETED AND VE IMPLEMENTED PROJECTS IN YEARS

Respondent	Project Completed					VE Implemented				
	< 2003	2004	2005	2006	2007	< 2003	2004	2005	2006	2007
1	50	4	3	3	3	5	2	2	3	3
2					4					
3	10	10	15	20	25	2	2	5	4	5
4			1	1						
5	30	2	1			9	2	1		
6	142	6	1	6	1					
7	2	3	2	2	4	1	1	1	2	3
8	5	3	3	2	1	1	1	1	1	1
9	5		3	1						
10	8	2	2	1	1					
11	6	1	1	2	2				2	2
12	4	1	1	1	1	4	1	1	1	1
13	1	1	2	4	1			2	3	
14			4	1				1		
15	19	34	35	28	40	19	34	35	28	40
16	1	2	2	1	2	1	1	1		1
17	5				1	5				1
18										
19	2	4		3	1	1				
20	20	1		1	2					
21	2	3				1				
22	19	2	2	1	2		2	2	2	2
23	2	2	4	2	2	2	2	2	2	2
24			1	1	2			1	1	2

APPENDIX 8: VE TOOLS USED BY CONTRACTORS THAT IMPLEMENT VE

Respondent	Implement VE?		Information Stage			Creative Stage			Analysis Stage				
	Yes	No	Function Analysis	Pareto Analysis	Full VE Job Plan	Creative Thinking	Brainstorming	Cost Model	Cost Function Analysis	Cost Breakdown Analysis	Evaluation Matrix	Life Cycle Cost	Other
1	1					1		1		1			1
2		1											
3	1				1	1				1			
4	1		1				1					1	
5	1								1	1			
6		1											
7	1					1	1			1			
8	1			1	1	1		1		1			
9		1											
10		1											
11	1		1			1	1	1	1	1			
12	1					1	1			1			
13	1					1	1			1			
14	1		1				1	1	1				
15	1					1	1			1			
16	1		1							1			
17	1					1	1						1
18		1											
19	1								1				
20		1											
21	1								1	1	1		1
22	1		1			1	1		1	1			
23	1					1	1			1			
24	1		1			1	1		1	1	1	1	1